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SURFACE SUPPLY CONVERSION.(U)
SEP 56 F J RICKER
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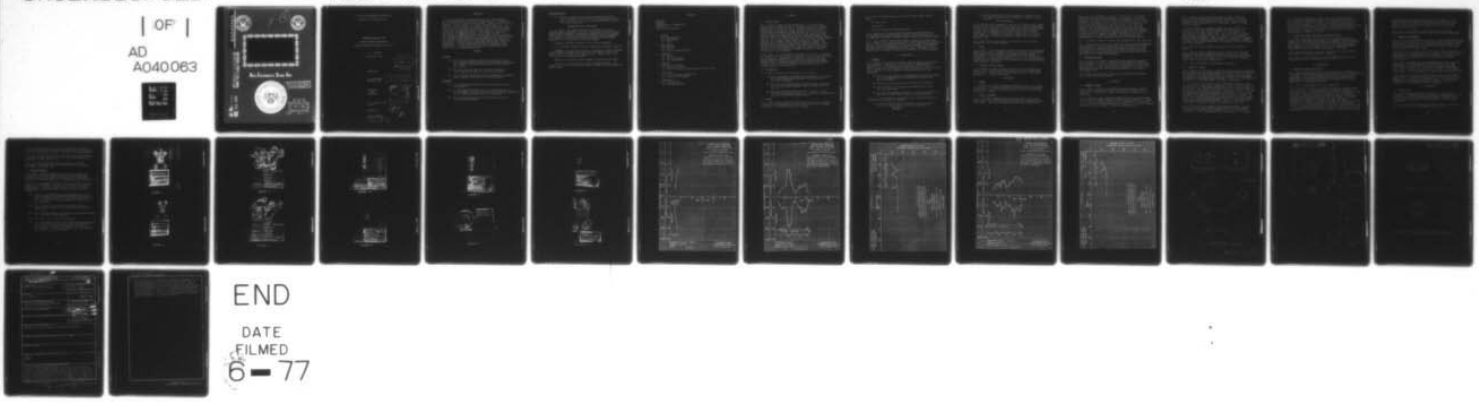

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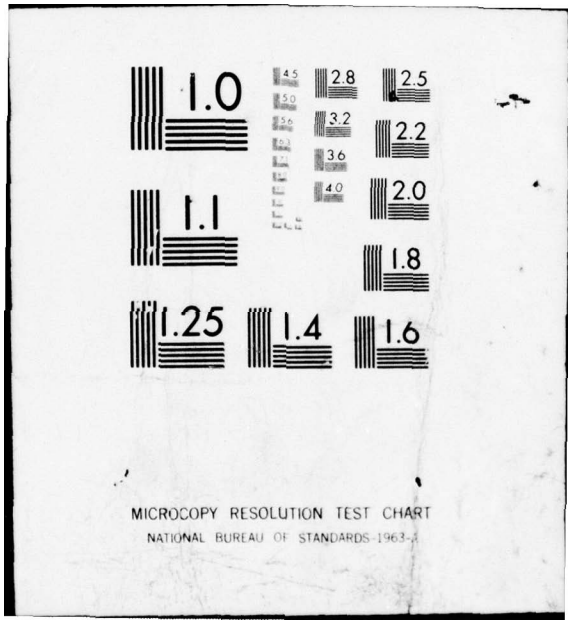
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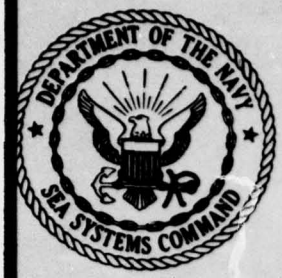

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U. S. NAVY EXPERIMENTAL DIVING UNIT

Panama City, Florida 32401

Research Report 2-57

Surface Supply Conversion

Project NS185-005 Subtask 4 Test 26

F. J. Rickert

28 September 1956

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Conducted

F. J. Rickert
BM1(DV), USN

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ABSTRACT

As a consequence of the removal of air hose supplied diving equipment from all 'non-diving' ships in the Navy and the substitution of scuba there arises a logistic as well as an emergency supply problem as regards high pressure air. In order to permit shallow dives such as hull inspections without depleting high pressure air bottles, a need is recognized for a means of adapting low pressure air supply to scuba demand regulators and breathing gear. A satisfactory adapter conversion rig was designed and tested. The results indicate that the Aqua-Lung regulator is not suitable for surface supply due to high inhalation pressures required for low (100 psi at surface) supply pressure. The Div-Air and Scott Hydro-Pak regulators are reported as satisfactory for surface supply conversion. A Scott Hydro-Pak mask with a commercial non-return valve is also tested and reported to function satisfactorily at low supply pressures.

SUMMARY

PROBLEM

(1) To design an adapter conversion rig to permit the use of scuba demand regulator and breathing components with surface supplied, low-pressure air in lieu of air bottles.

(2) Ascertain the suitability of various commercial demand regulators for use with surface-supply.

(3) Ascertain the suitability of the commercial non-return valve supplied with the Scott Hydro-Pak mask.

FINDINGS

(1) A suitable adapter conversion rig was designed and manufactured.

(2) The Aqua-Lung Regulator was found unsatisfactory for surface-supply conversion due to high inhalation pressures at low supply pressure (100 psi at surface).

(3) The Scott commercial non-return valve was found to operate satisfactorily.

RECOMMENDATIONS

(1) That no further steps be taken regarding surface supply conversion kits until the open-circuit demand scuba, furnished the fleet, operate satisfactorily at low supply pressures.

ADMINISTRATIVE INFORMATION

In view of the recent removal of conventional surface supplied diving equipment from all "non-diving" vessels and the substitution of scuba, the Bureau of Ships by letter file S94/1 (588) serial 588-562 of 10 March 1955 directed the development of a means of converting the demand regulator and breathing components of various scuba to surface supply

Project NS185-005, Subtask 4, Test 26 was assigned.

F. J. RICKERT, BM1(DV), USN was assigned as Project Engineer.

Subsequent to the above letter, the Bureau of Ships furnished a Scott Hydro-Pak Mask with commercial non-return valve to be tested for suitability for surface supply. This extension of the project was directed verbally.

Costs of this project were charged to Project Order 30026.

This is the first and final report of this project. The report is issued in the Research Report series of the Experimental Diving Unit.

CONTENTS

1. OBJECT

1.1 Introduction

1.1.1 Recent changes in the allowance lists of most "non-diving" vessels have removed all classical diving equipment (light-weight equipment, etc.). In most cases, open-circuit demand type scuba has been substituted to meet the light (and usually infrequent) diving requirements of these ships. In most cases, on such ships the use of the scuba would be limited to work or inspections on the underwater body of the ship and therefore would be limited to relatively shallow depths. Many of the so called "non-diving" ships are without high-pressure air systems, having only low pressure systems for general ship's service or for diesel engine starting. Since the self contained scuba requires air cylinders charged to 1800 psi it is anticipated that logistics problems may arise in the stocking and supply of charged cylinders or in the refilling of used cylinders.

1.1.2 Since, as stated above, the majority of dives conducted by "non-diving" vessels may be expected to be of shallow depths, it is considered desirable o provide a means of supplying surface (ship's service) air to the scuba demand valve and thereby conserve charged cylinders for emergency (and deeper) dives as well as to permit shallow diving even though no charged flasks may be available.

1.2 Objectives

1.2.1 The objectives of this project have been to:

(1) Design equipment to permit the adaptation of a surface air hose to existing commercial scuba valves and breathing equipment.

(2) Ascertain the feasibility of using several commercial makes of breathing equipment when supplied from the surface.

(3) Evaluate the Scott Hydro-Pak Mask (integral demand valve) with non-return valve (as supplied by manufacturer) for use as a surface supplied unit.

1.3 Scope

1.3.1 The project included the design and manure of equipment to permit the adaptation of various commercial scuba breathing components to an air hose from the surface.

1.3.2 The following demand valves were tested under surface supply

(1) Aqua-Lung

(2) Div-Air

(3) Scott Hydro-Pak (standard mask)

1.3.3 The scope of the project included the establishment of working drawings, specifications and an instruction book for the adapters required to permit surface supply to the above units.

1.3.4 The original scope of the project called for design and test of the adapters using only the U.S. Navy Standard Non-Return Valve. However, during the period of actual work on the project, the Scott Aviation Corporation supplied a standard Scott Hydro-Pak Mask with a commercial non-return valve. The scope of the project was broadened to include an evaluation of this equipment.

2. DESCRIPTION

2.1 General

2.1.1 Having selected the specific makes of demand valves to be considered for adaptation to surface supply (paragraph 1.3.2 above), general req irements for their use were considered. Since all but the Scott Hydro-Pak were designed for back mounting, it was decided to work towards a design providing for the following:

(1) Adapter to be mounted in approximately the same position as in back mounted de and regulators (between the shoulder blades).

(2) Equipment to be made for easy donning and release.

(3) Installation of a standard non-return valve at the adapter connection.

(4) Mounting the demand regulator in a position similar as possible to that used in normal scuba operations.

2.1.2 A study of the four equipments to be considered lead to an initial segregation as follows:

(1) Equipment wherein demand regulator was to be back mounted using a medical yoke type connection.

Aqua-Lung
Div-Air

(2) Equipment wherein demand regulator is integral with the mask requiring a hose connection from air source to mask.

Scott-Hydro-Pak

2.1.3 Though it is recognized that the old shallow water diver equipment (Jack Brown Mask) did not provide a demand regulator, it was decided that the urface supply conversion would provide for use of the regulator. It was felt that the air saving feature and the warning feature upon failure were distinct advantages. In addition, it would be impossible for a diver with mouth-bit breathing apparatus to work with a continuous supply of air.

2.1.4 The decision was made to use the U.S. Navy Standard Non-Return Valve at the adapter.

2. Tests

2.2.1 Since all of the demand valves considered were commercial models and primarily designed for supply pressure ranges above 200 pounds, it was necessary to determine the operating characteristics for supply pressures in the range of 100 psi. It was also considered desirable to determine breathing pressure (inhalation and exhalation) and respiratory rate characteristics under working conditions.

2.3 Scott Non-Return Valve

2.3.1 Figure 8 shows an exploded view of the commercial non-return valve supplied with the standard Scott Hydro-Pak mask. The valve is spring loaded and has a fabric seat. The valve appears to be simple and durable.

3. PROCEDURE

3.1 Design

Based on the basic principles described above, the surface supply conversion adapter described in (4) below was designed by personnel of the Experimental Diving Unit and manufactured in the Unit's shops.

3.2 Tests conducted

3.2.1 Subjective swimming tests were run with each of the three equipments using surface air at 100 psi supplied through the adapter. Runs of 30 minutes duration were conducted at

work rates as indicated in Figures 11 through 15. The diver initially worked (swimming) against a six pound pull on the underwater trapeze. This work rate is equivalen to 0.75 knot swimming. The descent to the depth of 50 feet was made slowly to per it instrument checks at each 10 feet. At time ten minutes (having reached 50 feet) the diver's work rate was increased to the equivalent **of** 0.88 knot swimming for five minutes. At time 15 minutes the diver rested for five minutes. At time 20 minutes the diver simulated manual work by lifting a weight of 67 1/2 pounds (in water) a height of 28 inches at the rate of 10 times per minute. This work rate was maintained until the beginning of ascent at time 30 minutes.

3.2.2 A working depth of 50 feet was specified for each test run.

3.2.3 Subsequent to test runs with the locally designed adapters, the Scott Hydro-Pak unit with commercial non-return valve was given subjective tests with 100 psi supply diving to 50 feet in order to test the non-return valve and to verify that the breathing characteristics did not vary with those found during the previous run (with EDU adapter).

3.3 Instrumentation

3.3.1 In order to measure inhalation and exhalation pressure for the subjective runs a one-pound strain gage was rigged in the breathing circuit and, with proper attenuation and frequent calibration, pressure readings were continuously recorded. The reference top for the strain gage was rigged at the depth of the demand valve.

3.3.2 The breathing rate (breaths per minute) were measured by counting wherever possible.

4. RESULTS

4.1 Adapter design

4.1.1 After a study of the problem, the back mounted Surface Supply Conversion Adapter shown in Figures 1 through 4 was developed. Figures 16, 17 and 18 are detailed drawings of the equipment.

4.1.2 Figures 1 and 3 show the adapter as made up for mounting of yoke mounted demand regulators (Aqua-Lung and Div-Air). Figure 5 is the yoke coupling adapter piece showing the teflon washer at the connection between adapter and regulator. The Navy standard non-return valve is shown in the operating position.

4.1.3 Figures 2 and 4 how the adapter as made up for use with the Scott Hydro-Pak mask mounted regulator. The yoke coupling adapter is replaced by a hose adapter to which the supply air hose from the mask is connected. Figure 6 shows the hose adapter.

4.1.4 The adapter is strapped across the divers' back for location between the shoulder blades that the demand regulators (Aqua-Lung and Div-Air) are in essentially the same position as when using scuba. The back-plate and canvas strap harness assembly is shown in Figure 10. The adapter holder, shown in Figure 7, has the specific function of holding the yoke adapter off the diver's back in a position to permit mounting of the demand regulator. The adapter holder is screwed onto the back-plate.

4.1.5 The U.S. Navy standard non-return valve is shown in Figure 9.

4.1.6 During initial subjective runs, it was found that the adapter holder became loose from the back-plate by rotating slightly. In order to prevent this, a keeper plate was welded to the back-plate. The keeper plate may be seen in Figures 1 and 2 and is indicated on Figure 16.

4.1.7 All metal parts of the adapter are brass.

4.2 Subjective tests

4.2.1 Figure 11 is a curve of the breathing pressure vs time for the Aqua-Lung Regulator when rigged for surface supply of 100 psi. At 30 foot depth, the inhalation pressure was 9 cm. at 50 feet Corresponding exhalation pressures are indicated in the Figure. The run was discontinued upon reaching 50 feet due to the subject's difficulty in breathing against so high a resistance.

4.2.2 Figure 12 is a curve of the breathing pressure vs time for the Div-Air regulator as rigged for surface supply of 100 psi. At 20 feet depth the inhalation pressure was 8 cm, increasing to 10 cm at 50 feet. While at 50 feet under high exertion (0.88 knot swimming) the inhalation resistance increased to 28 cm. At rest the exhalation pressure dropped to approximately 5 cm and then increased again under the moderate work of lifting weights. As expected, the inhalation pressure varied directly with the work rate. The overall breathing characteristics of the valve while surface-supplied were satisfactory. Figure 13 indicates the respiratory breaths per minute for the Div-Air test run.

4.2.3 Figure 14 is a curve of the breathing pressure vs time for the standard Scott Hydro-Pak mask (with integral demand regulator) rigged for surface supply of 100 psi through the standard U.S. Navy light-weight non-return valve. At a depth

of 30 feet, the inhalation pressure was 6 cm, increasing to 9 cm at 50 feet under light work. The inhalation pressure rose to 15 cm under 0.88 knot swimming and reached a peak of 20 cm while lifting weights. The exhalation pressure, as expected, varied with the inhalation pressure. The breathing characteristics of the Scott mask using surface-supply conversion were quite satisfactory. Figure 15 indicates the respiratory breaths per minute during a portion of a run.

4.3 Scott Mask with commercial non-return valve

4.3.1 The Scott Mask with non-return valve (Figure 8) was rigged on a dummy head, and tested in a chamber. The simulated surface-sup lied air was controlled from outside and the chamber was pressurized to a depth of 66 feet. When the supply hose was suddenly vented to atmospheric pressure (surface pressure) there was only a 0.8 psi drop in pressure at the mask.

4.3.2 After the above simulated "squeeze", the valve seat was inspected and found to be in good condition.

4.3.3. The curves of Figures 14 and 15 may be applied to the Scott Mask with non-standard non-return valve.

5. DISCUSSION

5.1 Surface supply adapter rig

5.1.1 The back mounted surface supply adapter as designed for this project and as described above is considered to be sufficiently successful. The rig is adaptable to either yoke mounted type regulators or to integral mask-regulator types (wherein the major function of the adapter rig is to provide a non-return valve and hose coupling location).

5.1.3 The entire adapter rig is non-magnetic.

5.1.4 During the tests the surface supply hose was left loose from the diver. In actual practice it will be necessary to secure the hose to the diver's person in order to prevent strain on the hose fitting. The surface supply rig, as designed, presents a good opportunity to remove the supply line from its usual securing spot at the weight belt and secure it to the adapter rig. This will then free the belt for quick, unencumbered release. A pad-eye or staple can readily be fitted to the center of the base plate at the base of the adapter holder. A securing lanyard can be bent onto life-line and supply hose and snapped to the pad-eye or staple. Though there is the disadvantage that the hose, being behind (and generally tending

upwards) the diver, might not be as easy to reach as if it were attached to the belt; this problem can readily be overcome as a matter of training the diver either to roll and reach for the line or to work with a bit of the life line and hose under his arm.

5.1.5 The entire surface supply adapter rig is readily adaptable to any sort of quick release belt buckle arrangement.

5.2 Commercial equipment

5.2.1 The tests described in section 4.2 above indicate that the Aqua-Lung regulator is not suitable for use at low pressures and therefore is not suitable for surface-supply conversion. This fact is unfortunate since the majority of scuba in service at the present time are Aqua-Lungs.

5.2.2 The tests of both the Div-Air and the Scott equipment (Figures 12 through 15) indicate he general suitability of these regulators for low pressure, surface supply. Of the two, the Scott regulator provides the most satisfactory breathing characteristics.

5.2.3 The Scott mask with the commercial non-return valve was also found to be satisfactory for shallow water use. The breathing characteristics of the mask (integral regulator) are the same whether using the Navy or commercial non-return valve. The commercial non-return valve appears to be equal in performance to the Navy standard shallow water non-return valve.

5.2.4 Though, at the time of the report there are no chest mounted demand regulators approved for use in the field, their possible approval has been considered and it is noted that the harness of the conversion rig could readily be modified to provide a means of snapping them on in front.

6. CONCLUSIONS

6.1 Conclusions

6.1.1 It is concluded that the design of a light weight non-magnetic adapter rig for surface-supply conversion of scuba demand regulators and breathing equipment is feasible, and that the design proposed in this project is satisfactory as a prototype.

6.1.2 The prototype adapter rig is well suited to cheap and rapid manufacture. It is simple to rig and use.

6.1.3 The current model of the Aqua-Lung demand regulator is not suitable for low pressure use and therefore may not be used for surface-supply diving. Wear with a suitable adapter.

6.1.4 The Div-Air regulator and the Scott mask with integral regulator are both suitable for use with surface-supply air through a suitable adapter rig.

6.1.5 The Scott mask with integral regulator and with commercial non-return valve is suitable for surface supply use without an adapter rig.

6.2 Recommendations

6.2.1 Since the majority of scuba now in use in the Navy are Aqua-Lung and since the Aqua-Lung is not suitable for surface supply, there appears to be no merit in proceeding farther with the development or a distribution of a conversion rig.

6.2.2 It is recommended that every consideration be given to improve the operational readiness of the fleet units by the incorporation of surface supply adapters with open circuit demand Scuba. Suggested steps to take in this regard are as follows:

(1) Include a requirement in the specification for the demand regulators (MIL-R-19558 (SHIPS) that the valve perform satisfactorily to a depth of 50 feet with a constant supply of 100 psi supplied through 100 feet of oxygen hose.

(2) At the proper time, contract for production of a sample lot of adapters as designed and discussed in this report.

(3) Instruct this activity to prepare an instruction manual for field test of the adapters.

(4) Schedule a field test of the adapters.

(5) Place the adapters that result from the recommendations of the field tests in standard stock and instruct this activity to prepare a change to the U.S. Navy Diving Manual to advise the fleet of the availability and proper use of the adapters.

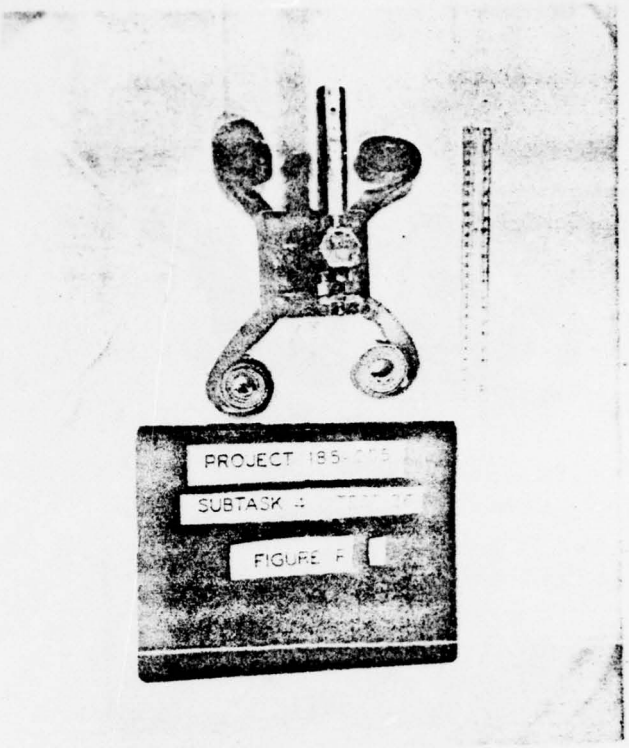


FIGURE 1

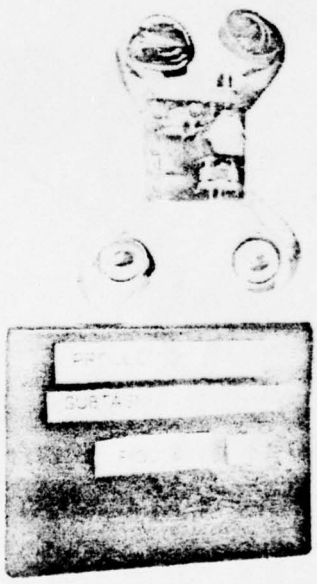
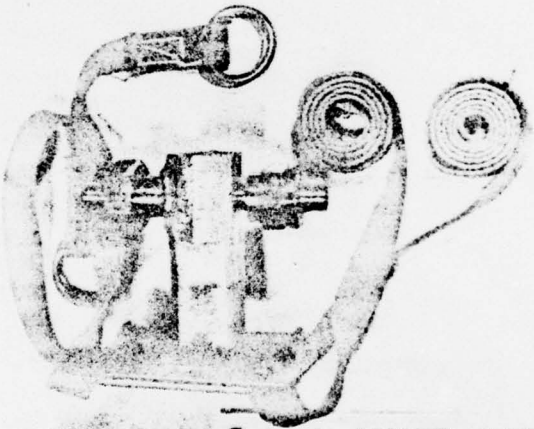


FIGURE 2

Project NSI85-005
Subtask 4
Test 26
SCUBA
SURFACE SUPPLY
CONVERSION

FIGURE 3



Project NSI85-005
Subtask 4
Test 26
SCUBA
SURFACE SUPPLY
CONVERSION

FIGURE 4

FIGURE 5

FIGURE 6

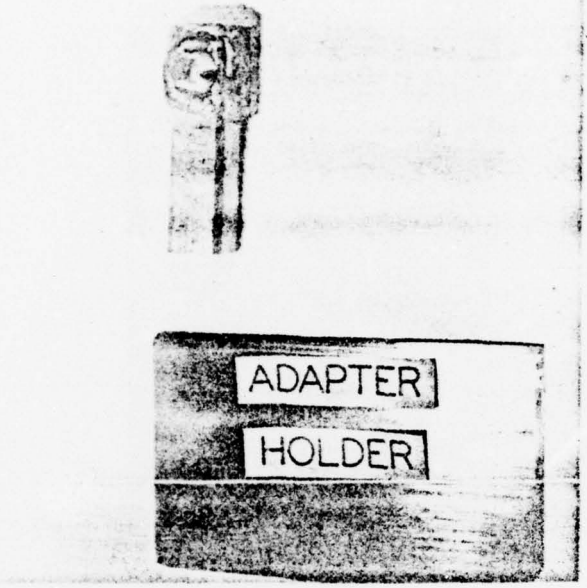


FIGURE 7

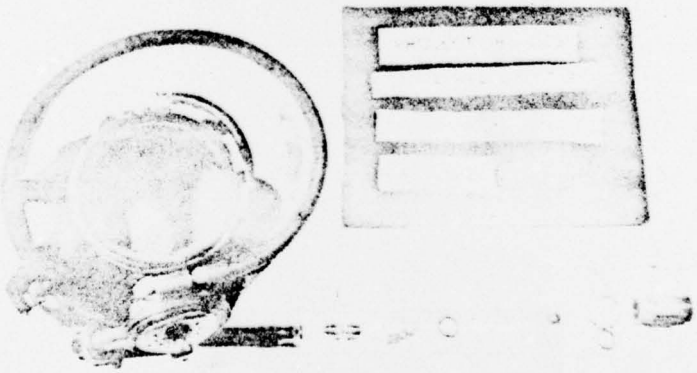


FIGURE 8

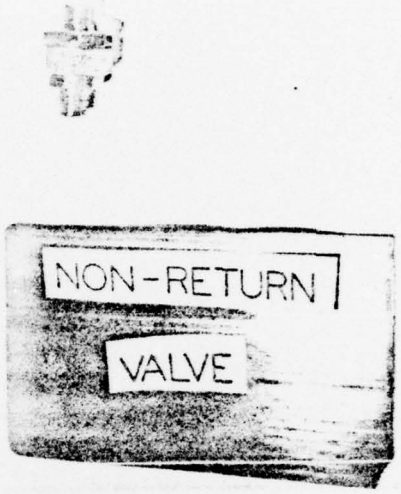


FIGURE 9

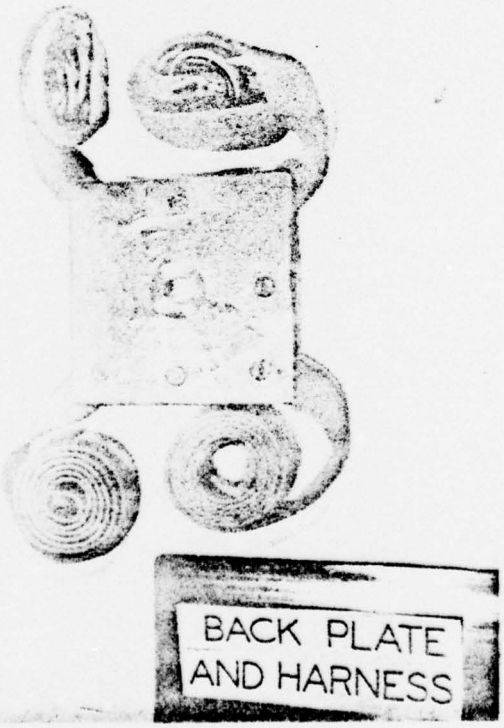


FIGURE 10

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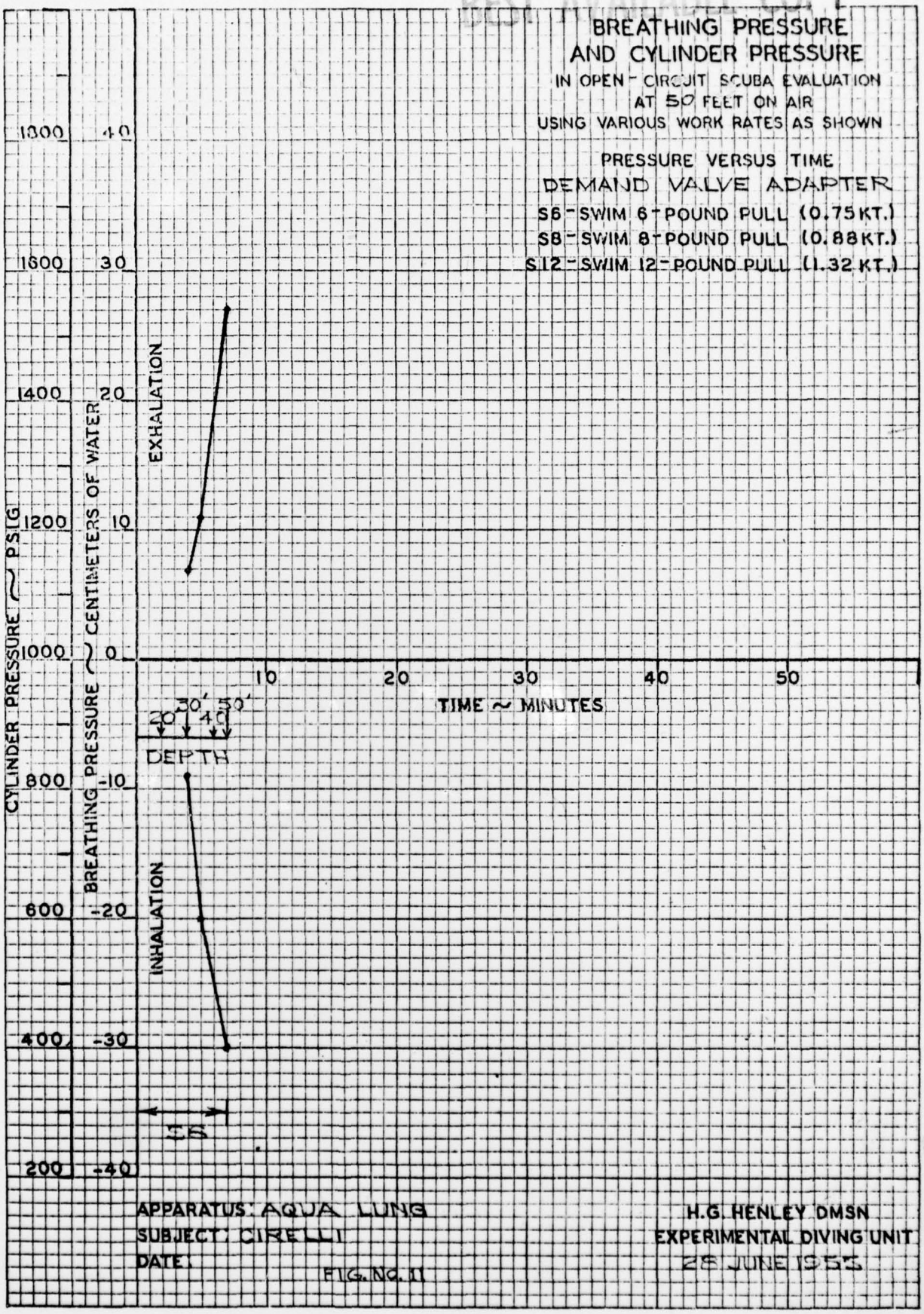

FIG. NO. 11

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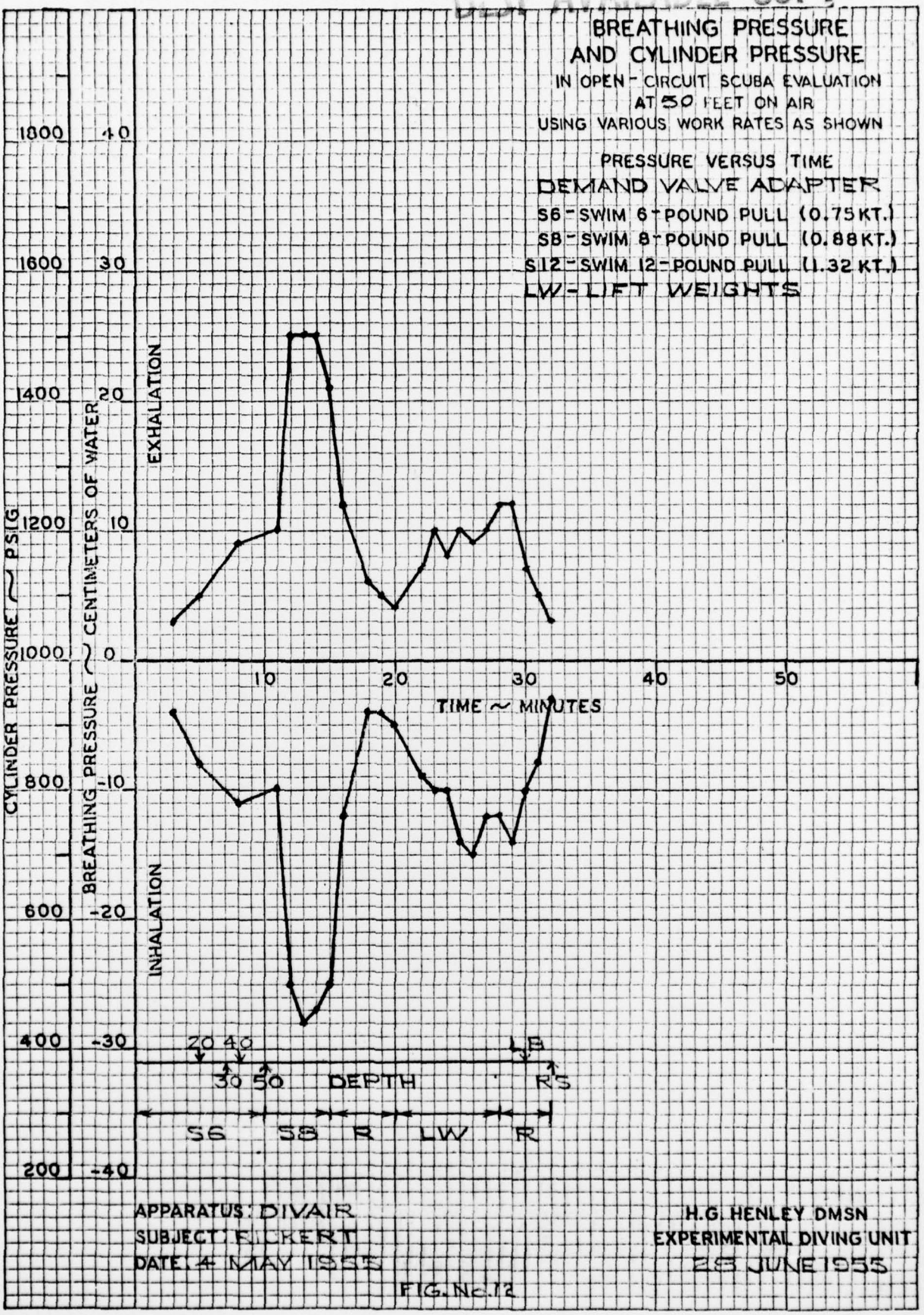

FIG. No. 12

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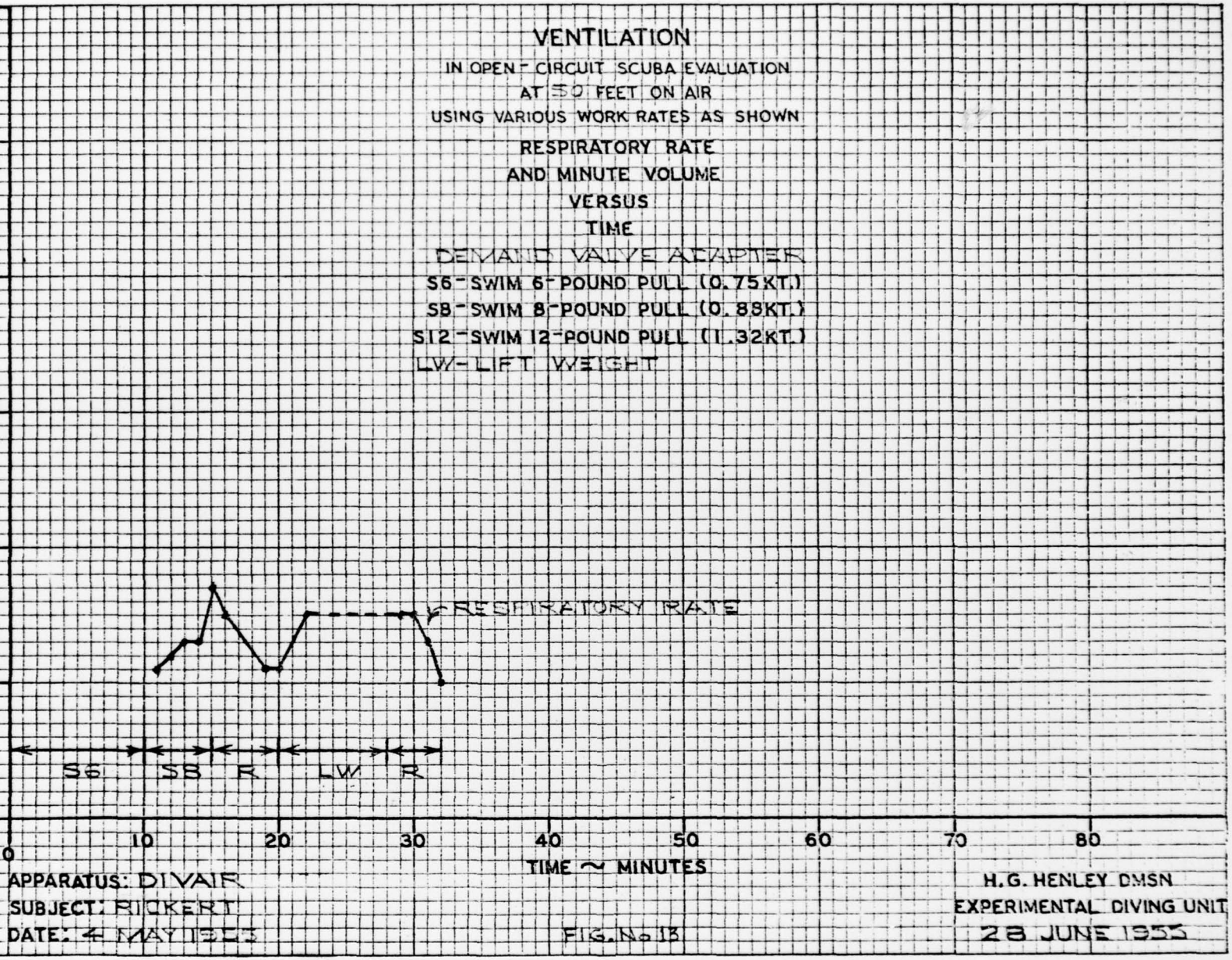
VENTILATION

IN OPEN-CIRCUIT SCUBA EVALUATION
AT 50 FEET ON AIR
USING VARIOUS WORK RATES AS SHOWN

RESPIRATORY RATE
AND MINUTE VOLUME
VERSUS
TIME

DEMAND VALVE ADAPTER

S6 - SWIM 6-POUND PULL (0.75 KT.)
S8 - SWIM 8-POUND PULL (0.88 KT.)
S12 - SWIM 12-POUND PULL (1.32 KT.)
LW - LIFT WEIGHT



APPARATUS: DIVAIR
SUBJECT: RICKERT
DATE: 4 MAY 1955

FIG. No 13

H.G. HENLEY DMSN
EXPERIMENTAL DIVING UNIT
28 JUNE 1955

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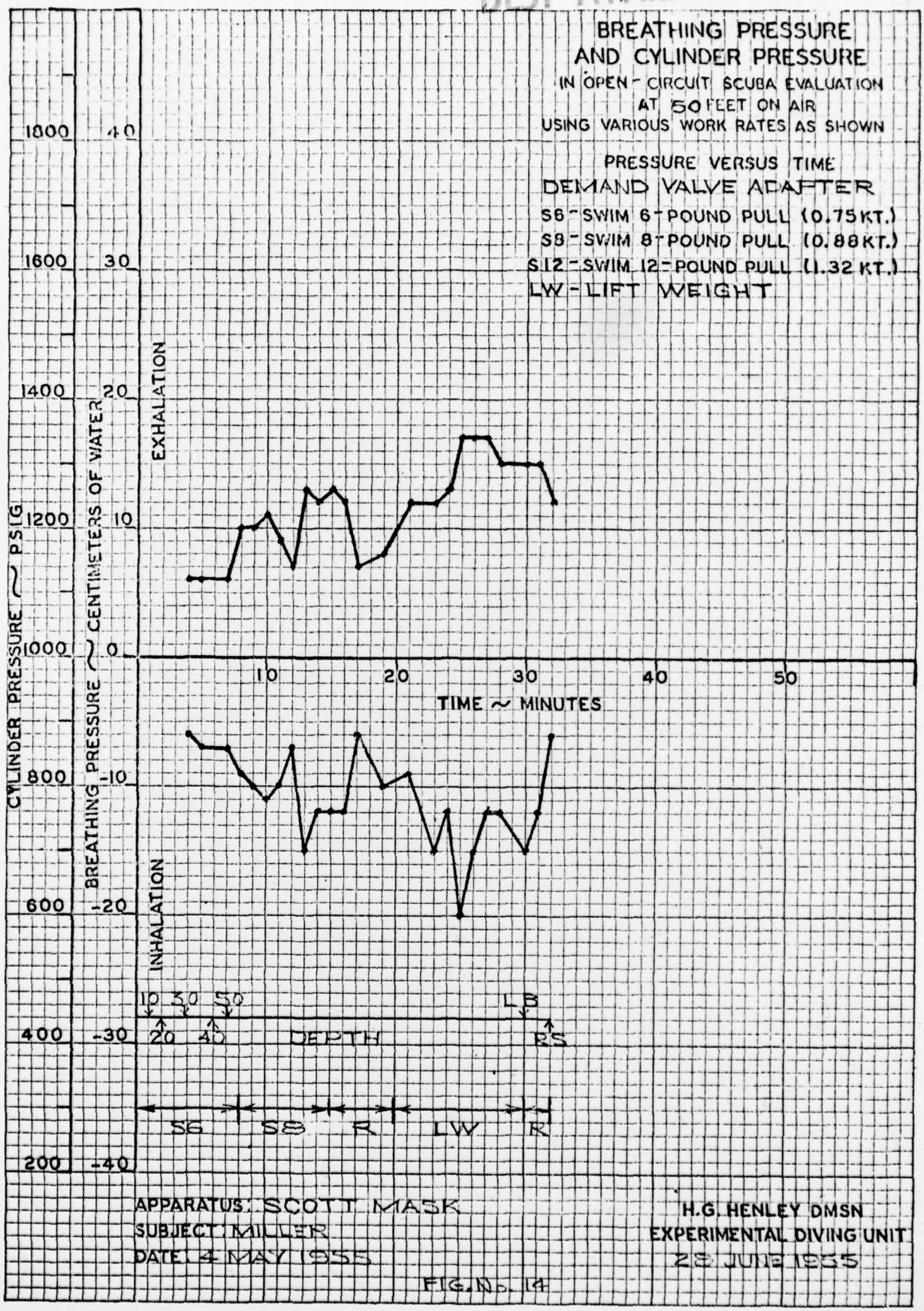


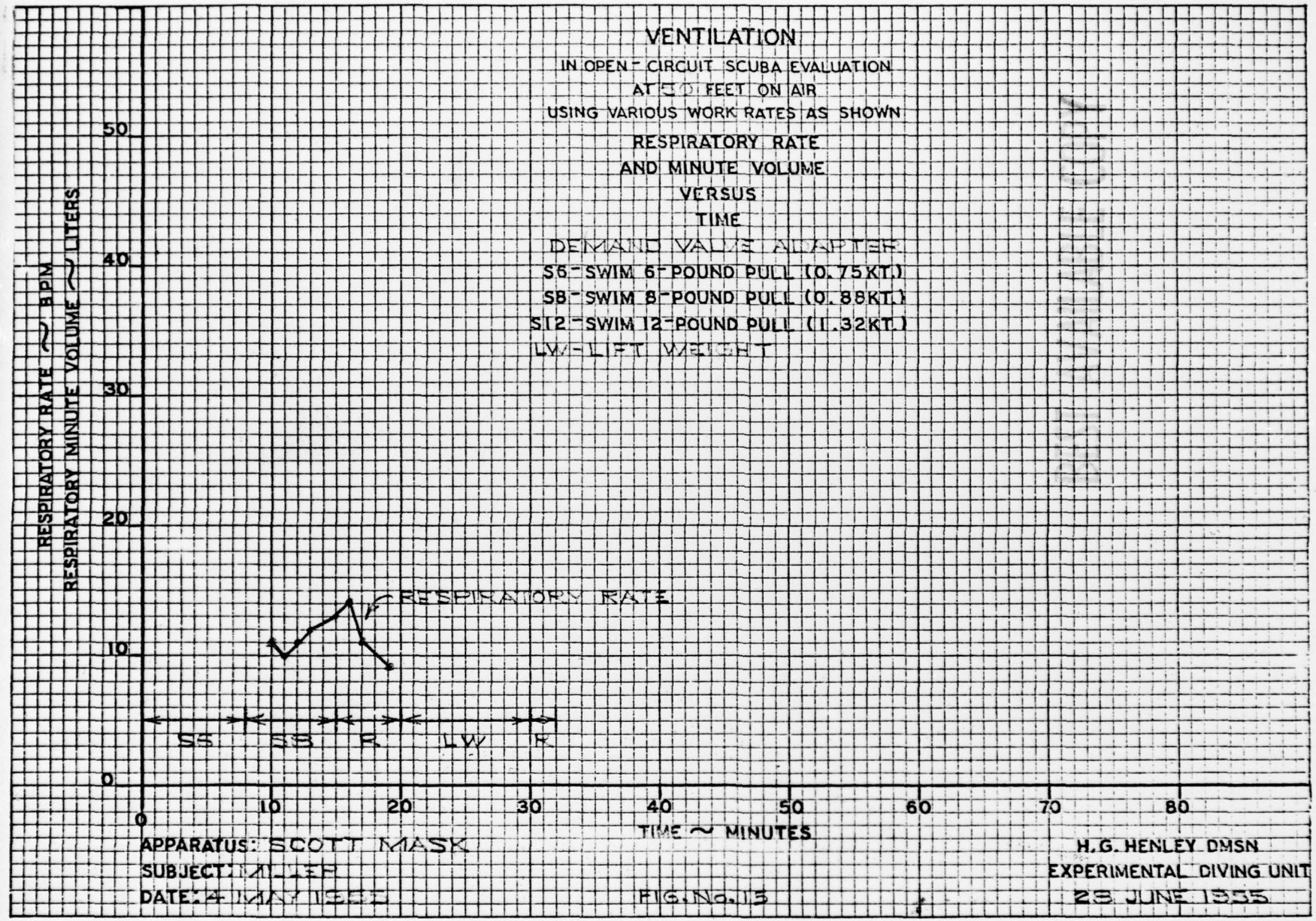
FIG. No. 14

VENTILATION

IN OPEN - CIRCUIT SCUBA EVALUATION
AT 50 FEET ON AIR
USING VARIOUS WORK RATES AS SHOWN

RESPIRATORY RATE
AND MINUTE VOLUME
VERSUS
TIME

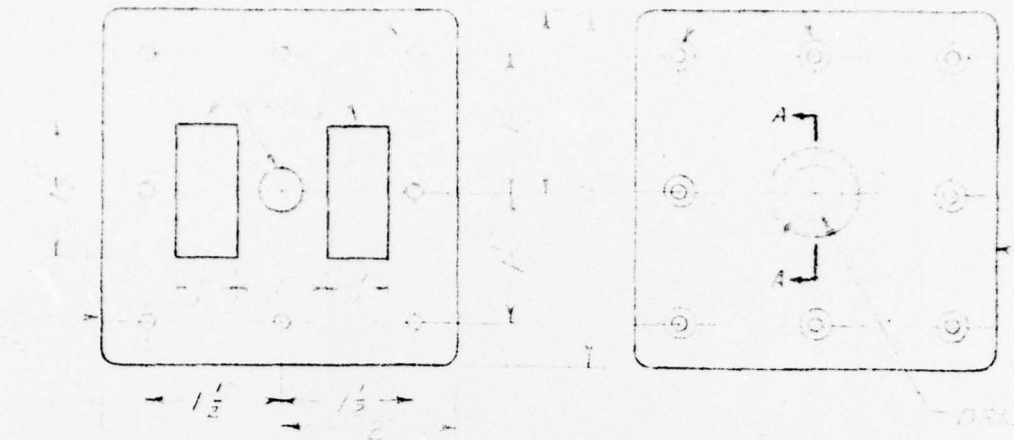
DEMAND VALVE ADAPTER
S6 - SWIM 6-POUND PULL (0.75 KT.)
S8 - SWIM 8-POUND PULL (0.88 KT.)
S12 - SWIM 12-POUND PULL (1.32 KT.)
LW - LIFT WEIGHT



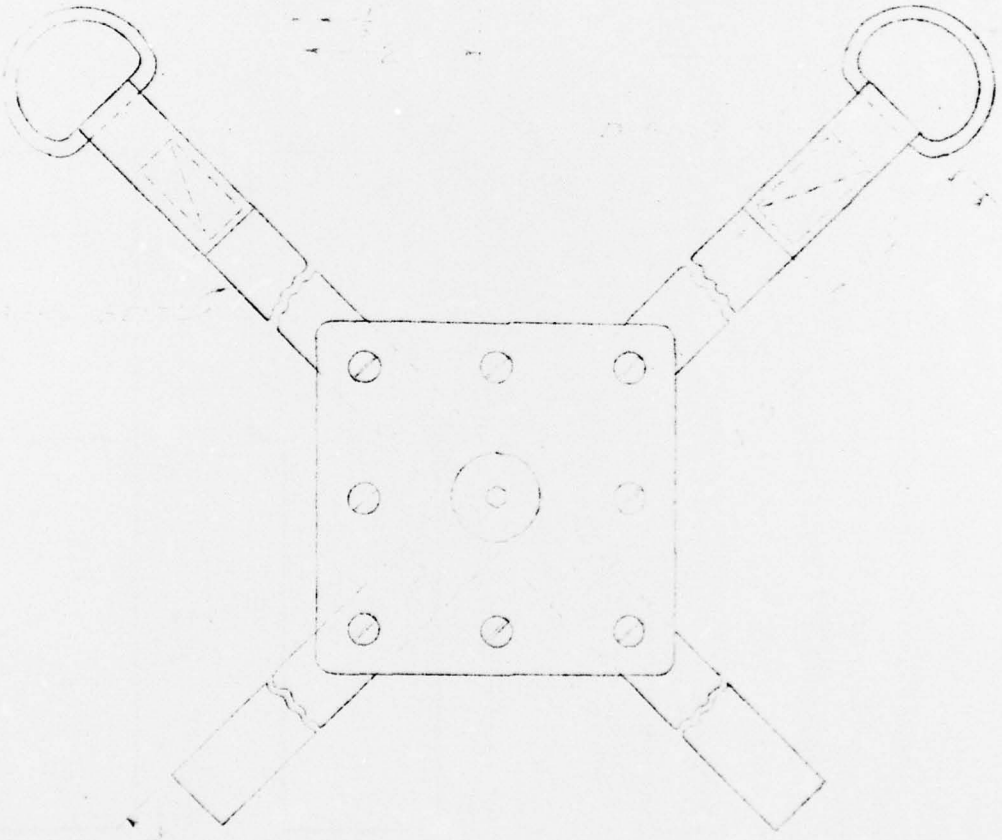
APPARATUS: SCOTT MASK
SUBJECT: MILLER
DATE: 4 MAY 1955

FIG. No. 13

H. G. HENLEY DMSN
EXPERIMENTAL DIVING UNIT
23 JUNE 1955



EACH PLATES



BACK PLATE ASSEMBLY

SCALE 6"=1'0"

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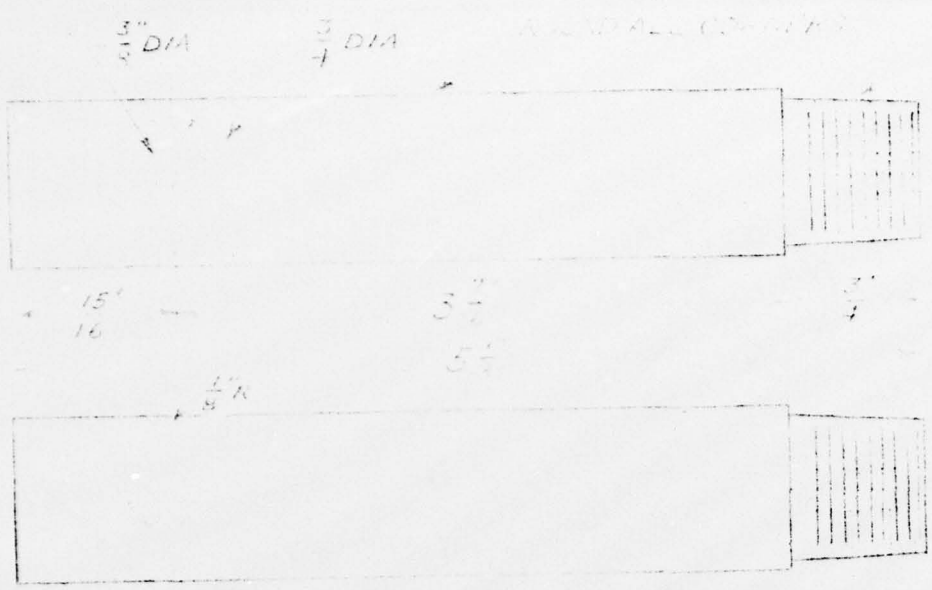
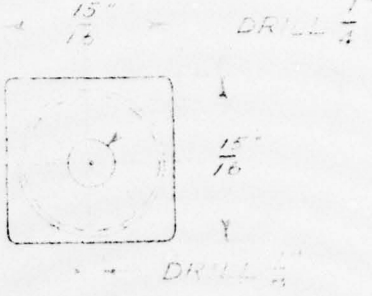
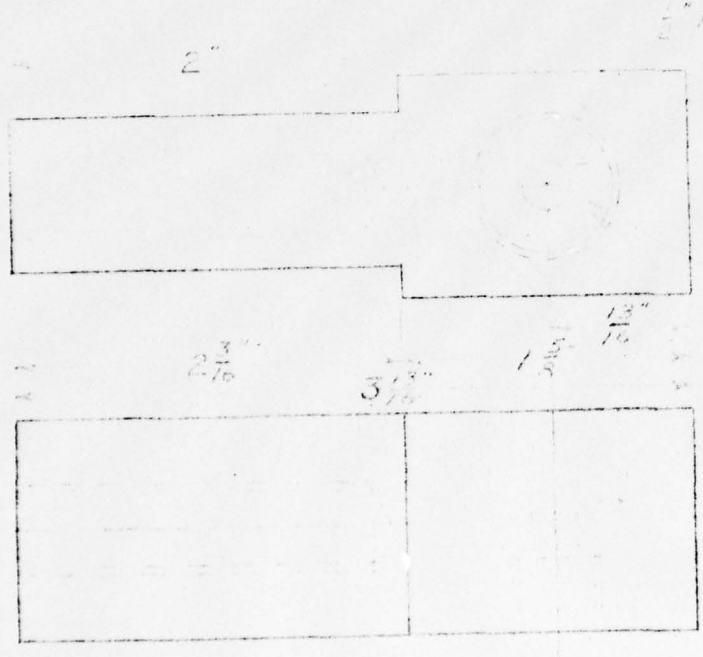


YOKE ADAPTER





ADAPTER HOLDER

Fig No. V

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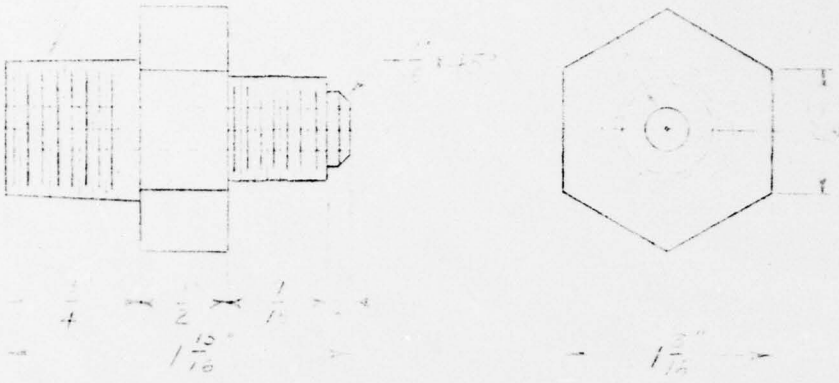
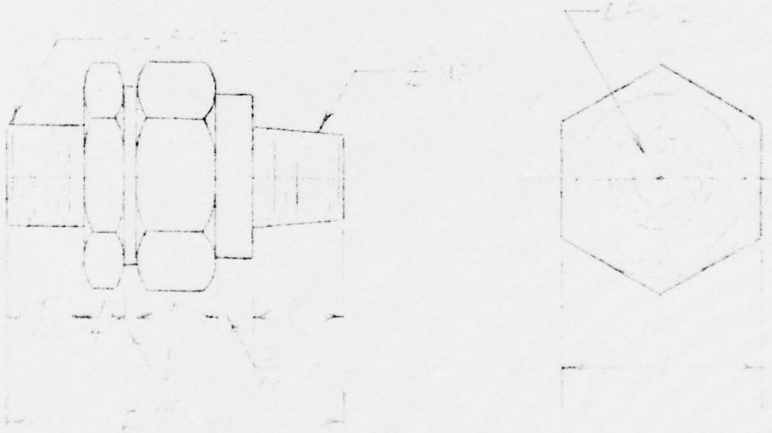


SCOTT MASK ADAPTER



STANDARD NON-RETURN VALVE

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Surface
Supply
Mask

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

As a consequence of the removal of air hose supplied diving equipment from all "non-diving" ships in the Navy and the substitution of scuba there arises a logistic as well as an emergency supply problem as regards high pressure air. In order to permit shallow dives such as hull inspections without depleting high pressure air bottles a need is recognized for a means of adapting low pressure air supply to scuba demand regulators and

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20. breathing gear. A satisfactory adapter conversion rig is designed and tested. The results indicate that the Aqua-Lung regulator is not suitable for surface supply due to high inhalation pressures required for low (100 psi at surface) supply pressure. The Div-Air and Scott Hydro-Pak regulators are reported as satisfactory for surface supply conversion. A Scott Hydro-Pak mask with a commercial non-return valve is also tested and reported to function satisfactorily at low supply pressures.